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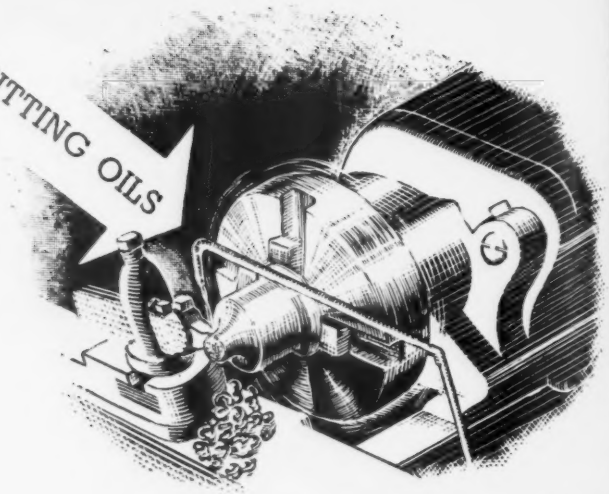

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AVIATION GAS TURBINE ENGINES*

By S. A. W. THOMPSON

MOST people are familiar with the way in which a piston engine works, but until recently the functioning of the gas turbine has been something of a mystery. There is a fundamental similarity between the two types of engines, in both the working medium is air, which is compressed, heated by burning fuel in the air, and work is then done by the expansion of the heated bases.

The difference is that in the piston engine the whole process is carried out on a "batch basis" in one vessel, i.e., the various steps in the cycle are accomplished by opening valves into the cylinder, and by altering its shape by moving the piston up and down.

In the turbine engine there is a continuous flow process in which the gas is first fed into the compressor, the compression cycle is performed; thence into the combustion chamber where the air is heated up; the final expansion stages, where the work is done, take place in the turbine and in the jet pipe.

In the conventional petrol piston engine the combustion takes place under more or less constant volume conditions (while the piston is at about top dead centre on the compression stroke). The resultant heating of the air causes a rapid rise in pressure and temperature, and the work done depends on the difference between the high pressure and temperature at the beginning of the expansion stroke, and the pressure, and temperature at the end of the stroke when the exhaust valve opens.

In the gas turbine (Fig. 1), combustion takes place continuously and more or less at constant pressure, which results in a big expansion in volume of the working medium. Thus, the energy is put into the working medium in the form of an increase in temperature, e.g., from say 210° to 840° C, and an increase in the speed with which the air is going through the machine, e.g., from Mach No. 0·045 to 1·07. During the expansion through the turbine there is a reduction in gas

* Read before London Branch, Institute of Petroleum, on November 23, 1948.

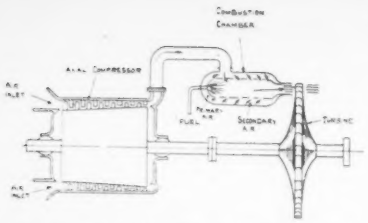


Fig. 1.—Gas turbine power plant with axial flow compressor

temperature and pressure corresponding to the work done in driving the turbine. The energy remaining in the gas may then be used to provide "propulsive thrust", that is to say, the reaction on the engine of the jet of hot gas issuing from the tailpipe is the force which pushes the aircraft along. As a matter of interest, the temperature in the jet pipe is about 500° C and the gas speed is Mach No. 0·91 or some 1100 m.p.h.

Historical

Although gas turbines have only become a practical proposition during the last few years, people have been toying with the idea of the gas turbine for a very long time.

The first real gas turbine appears to have been thought of by Leonardo da Vinci, who invented the "smoke jack" in 1648. *The Leonardo "Smoke Jack"* (Fig. 2) was really an industrial gas turbine intended to be used for "turning a spit, rocking a cradle, or chiming bells".

In 1791, an Englishman named John Barber took out a patent (No. 1833) for a gas turbine (Fig. 3) comprising:

(1) distillation of gas from wood, coal or oil,

(2) its combustion with the correct amount of air in the combustion chamber,

(3) discharge of the final fluid through a nozzle on to the turbine blades,

(4) provision for water injection into combustion chamber to cool the gases and augment their volume.

These proposals came surprisingly close to modern principles, and it was claimed in the patent specification that this engine could be used for operating hammers, winches, grinding and spinning machinery, and "for any kind of motion whatsoever".

This patent was followed by numerous others, mainly British, French, and later German. The important landmarks were:

1850 *Joule propounded basic thermodynamic cycle for gas turbines;*

1884 *Parsons patent for steam turbine included reference to the gas turbine and anticipated the axial flow compressor.*

Much theoretical and practical work was done in the twentieth century, the first large-scale unit manufactured to develop sufficient power to drive the compressor and to do useful work was run

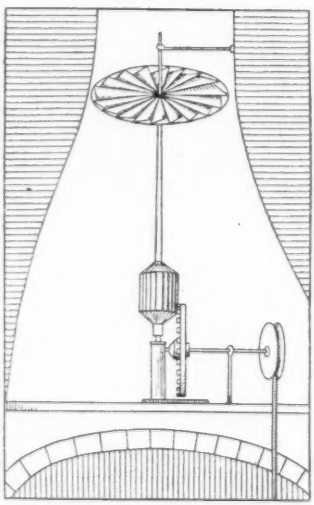


Fig. 2.—The Leonardo "Smoke Jack"

by the Société de Turbomoteurs of Paris in 1905. The fuel consumption of this engine amounted to $4\frac{3}{4}$ lb/b.h.p., equivalent to 3 per cent thermal efficiency. This engine used an axial flow compressor and burnt kerosine as fuel.

The efficiency of the gas turbine unit as a whole is the product of the efficiencies of the compressor, combustion chamber, and turbine. These early efforts were unsuccessful because the efficiencies of the compressors and turbines were too low owing to lack of the necessary knowledge of aerodynamics, and also because no materials were available which would permit the manufacture of a turbine with a sufficiently high gas entry temperature. Since the efficiency of the turbine is a function of the temperature drop across it, it was not really possible to make worth-while gas turbines until materials were available which would allow gas entry temperatures of above about 500° C.

Between 1931 and 1936, Lysholm in Sweden did a good deal of work on the gas turbine, and actually made an engine which was designed for flight purposes.

Some time before the war (1936–7) Brown Boveri designed and manufactured some industrial gas turbines, and one of the earliest practical applications is a gas turbine, which was run off the plant gases to drive a compressor used on a Houdry cracking plant erected for the Sun Oil Company in the U.S.A. (1500-kW unit, gas temperature 550° C).

In Germany, Heinkel designed and developed the first gas turbine engine ever to fly, although this first effort was not a success and the design was subsequently abandoned.

In the U.K., the work of Sir Frank Whittle and Dr Griffiths is well known, and the Power Jets' engine designed by Sir Frank Whittle may be described as the first successful engine to fly, since the engines fitted in the first Meteor aircraft to become operational were direct descendants of the early Whittle design.

The advantages of the gas turbine engine are—

(i) *Light weight and relatively small overall diameter;*

(ii) *Freedom from vibration due to the suppression of reciprocating parts;*

(iii) *Peculiar suitability of the turbine jet engine for high speed and high altitude operation;*

(iv) *Does not require the specialized high octane fuels needed by the piston engine.*

The disadvantages are:

(a) *Relatively low thermal efficiency and resultant high specific fuel consumption;*

(b) *Relatively short life;*

(c) *High speed of rotation, in the region of* 10,000 *r.p.m., involves a rather serious reduction-gear problem if the engine is to be used for driving a shaft.*

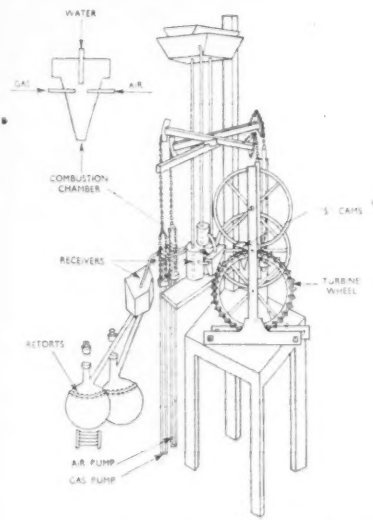


Fig. 3.—John Barber's gas turbine patent, 1791

It will be seen, therefore, that the gas turbine is a "natural" for aviation applications where low weight is of paramount importance. In addition, the principle of using the exit energy for driving the aircraft directly on the jet principle is particularly suited for high-speed applications.

Jet Engines

Fig. 4 shows a typical aircraft gas turbine jet engine, a Rolls-Royce design. In this arrangement the turbine is designed to take just enough energy out of the combustion gases to drive the compressor, and there is still a very considerable amount of energy left in the exhaust gases. It is this, what one might call, residual energy which is used in the jet pipe to provide the thrust which drives the aeroplane along.

It will be noted that the output of jet engines is described as so many lb thrust, whereas piston engine output is described in terms of h.p.

The thrust of the jet engine can be converted into equivalent h.p. by multiplying the thrust by the speed of the aircraft

1 lb of thrust being equal to 1 h.p. at 550 ft per second, or 375 miles per hour.

As an example, in order to produce the same results as a 3500 lb thrust engine driving an aircraft at 500 m.p.h., a piston engine of 4650 h.p. driving an airscrew of 100 per cent efficiency would be required, or about a 6000-h.p. engine driving a conventional airscrew.

Propellor Turbine Engines

An alternative arrangement of gas turbine engines is that shown in Fig. 5, the Armstrong-Siddeley Mamba rated at 1050 h.p. plus 300 lb jet thrust. With this arrangement much more energy is taken out of the combustion air by the turbine, and the excess over that required for driving a compressor is used to drive a propeller.

There are two quite different applications for the turbine engine, one is the pure jet, and the other the propeller turbine. Apart from the greater simplicity of the pure jet engine and, therefore, lower first and maintenance costs, the operator will choose the power plant which gives the greatest payload for a given range. The propulsive efficiency of the jet engine is a function of the difference between the forward speed of the aircraft, and the speed with which the jet gases come out of the back of the

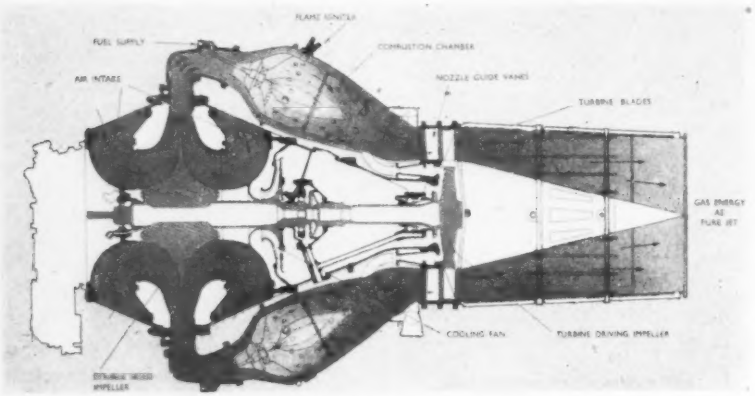
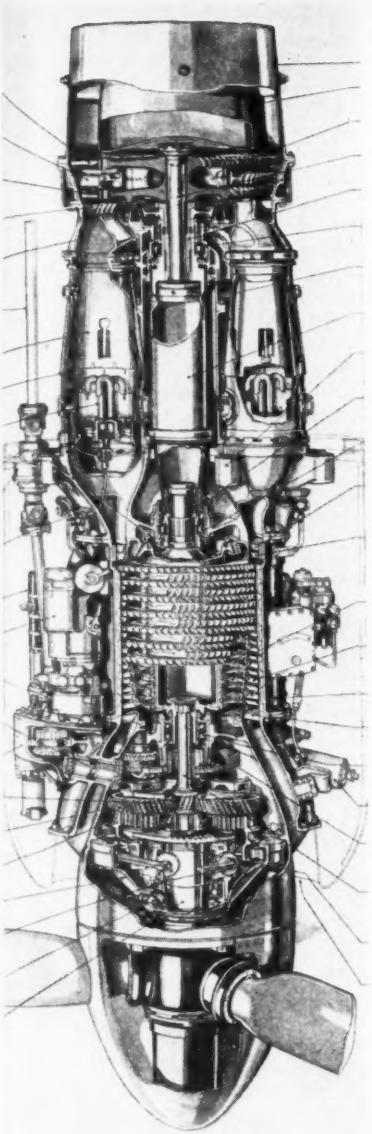


Fig. 4.—Rolls-Royce turbine engine



[Courtesy Flight

Fig. 5.—Armstrong-Siddeley Mamba

aircraft. In other words, the faster the aircraft, the higher the propulsive efficiency.

With the propeller, on the other hand, the propulsive efficiency is much higher at low speeds. It will be appreciated that the actual velocity of the propeller through the air is the sum of the rotational velocity of the airscrew round the engine and the forward speed of the aircraft. It will be seen, therefore, that at some aircraft speeds lower than that of the speed of sound, the tip of the propeller will be moving at the speed of sound, with resultant very severe increase in the drag of the airscrew blade, and consequent falling-off in airscrew efficiency. It will be seen that (Fig. 6) the efficiency curves for the jet and the propeller cross at about 550 miles per hour. In general, therefore, a designer will choose jet engines for high-speed aircraft, and propeller turbines for machines with operational speeds in the intermediate range.

There are certain basic differences between the engines manufactured by

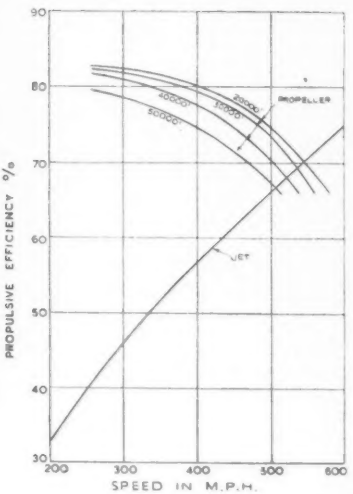


Fig. 6.—Comparisons of efficiencies of jet and propeller

the various firms. The outstanding difference between a Rolls-Royce engine (Fig. 4) and the de Havilland Ghost (Fig. 7) is that the Ghost uses a single-sided impeller similar in general design to that used on ordinary aircraft piston engines. The Rolls-Royce, on the other hand, uses a double-sided impeller.

The advantages of the single-sided impeller are that the entry of the air flow is almost unobstructed, and the forward speed of the aircraft is used to give a high air entry velocity into the compressor. The double-sided impeller is smaller in overall diameter for a given capacity, and can therefore be run to a higher speed for a given centrifugal loading at the edge of the blades. The compression ratio obtainable with single-stage centrifugal compressors is about 4 : 1, and efficiencies of higher than 75 per cent are very difficult to obtain.

Most of the early British jet engines used centrifugal compressors because the very considerable design experience accumulated as a result of work on piston engine superchargers could be applied more or less to this type. The Metropolitan Vickers Beryl (Fig. 8) uses an axial flow compressor rather like a steam turbine in reverse. With this arrangement it is possible to obtain higher compression ratios together with compressor efficiencies of over 80 per cent, and the overall diameter is considerably less for a given capacity. This type of compressor is, therefore, becoming more widely used as the necessary know-how in design and manufacture is accumulated.

The Goblin and the Derwent, as well as the majority of other turbine engines, use a number of small separate combustion chambers disposed axially round the centre line of the engine. The Beryl, on the other hand, uses a single annular combustion chamber instead of a number of small cans. With an annular combustion chamber the overall diameter can be kept smaller than if a number of individual combustion chambers are used. However, general maintenance and manufacture are more difficult and the testing of large annular

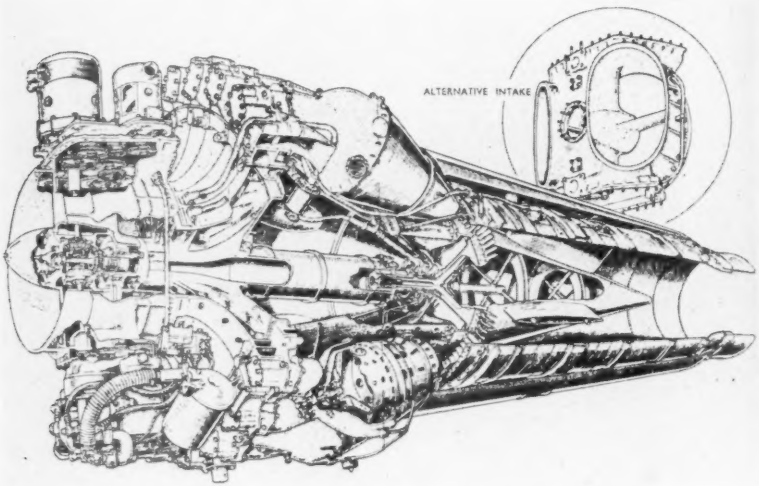


Fig. 7.—de Havilland Ghost

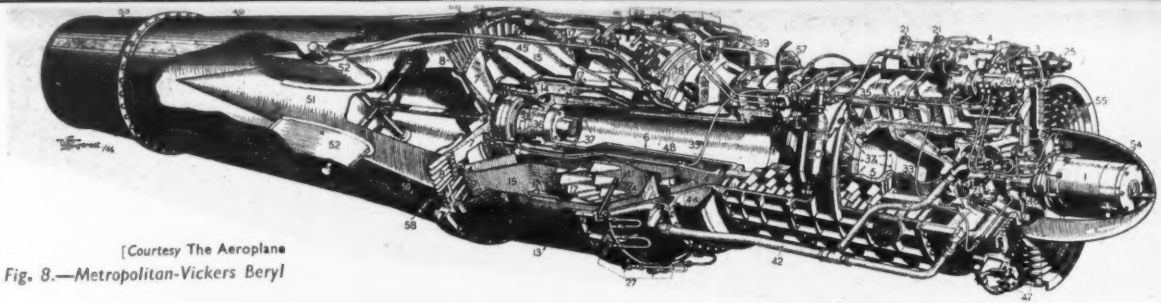


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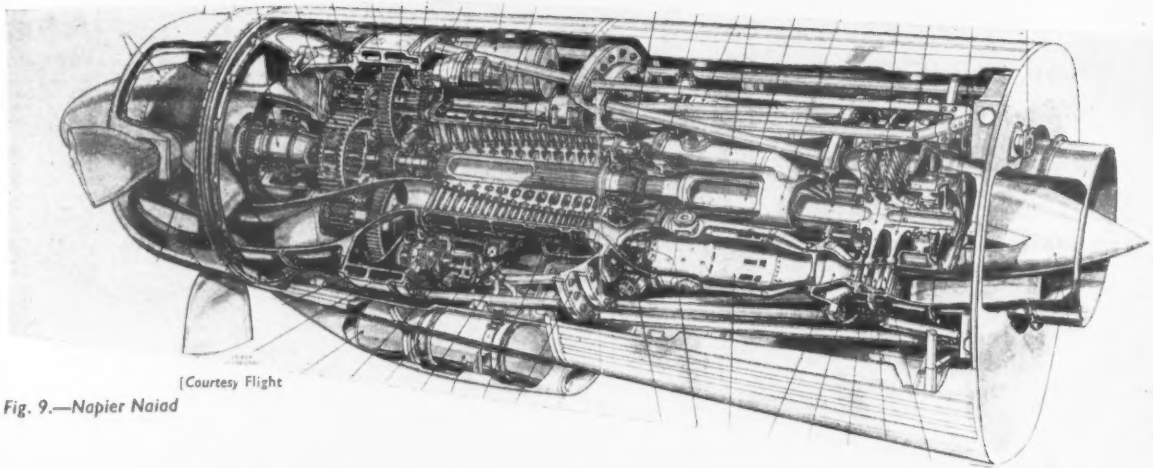
Fig. 8.—Metropolitan-Vickers Beryl



[Courtesy Flight

Fig. 9.—Napier Naiad

combustion chambers presents a very serious problem, since a compressor of the size of that to be used on the main engine must be employed in order to get an adequate air flow, whereas with the multi-chamber type, research and development can be carried out on individual combustion chambers with much less expensive test equipment.

Since the compressor for a 5000 lb thrust jet engine takes about 6000 h.p. to drive it, this is a very real objection to the annular combustion chamber, particularly for large engines.

The Napier Naiad (Fig. 9) is a 1500 h.p. propeller turbine engine using an axial flow compressor with the propeller driven through a 15 : 1 reduction gear from the front end of the compressor shaft. Incidentally, its maximum overall diameter is only 28 inches compared with 50 inches for a typical 1500-h.p. piston engine. This arrangement for the propeller drive is very simple, and a similar arrangement is used on another small propeller turbine, the Armstrong-Siddeley Mamba rated at 1050 h.p.

There are, however, some disadvantages in this scheme. If the compressor and turbine speed are fixed in relation to the airscrew speed it is possible to stall the compressor under certain flight conditions. Further, there is the starting problem. An axial flow compressor must be spun up to about 5000 r.p.m. before the engine will be self-sustaining, i.e., before the compressor will deliver enough air to enable the turbine to drive the compressor. This imposes quite a heavy load on the starter motor and if, in addition, the motors spin the propeller and reduction gear, a large and therefore relatively heavy starter must be employed. To overcome these objections the Bristol Theseus (Fig. 10) has two independent turbines, one driving the axial compressor and the other driving the airscrew. For starting purposes the compressor turbine shaft only is rotated, the airscrew turbine then starts up as soon as the compressor delivery reaches the required output.

Future Trends and Problems

The development of aviation gas turbines is now proceeding along fairly well established lines, and it is rather unlikely that any radical new design principles will emerge for some time. The emphasis is now on detailed refinements aimed at improving reliability, ease of manufacture, etc. There is no doubt that it will not be many years before jet engines can be run for 1000 hours between overhauls, the figure currently reached by the most highly developed piston engines in civil airline operation.

As an example of this trend, the de

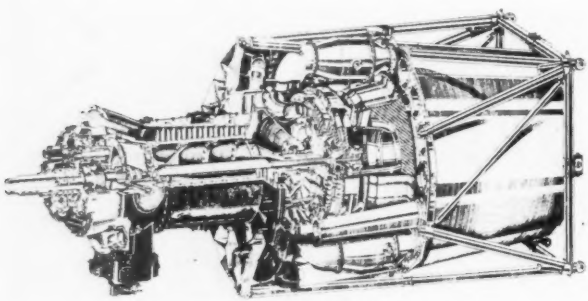


Fig. 10.—Bristol Theseus

Havilland Ghost, the Armstrong-Siddeley Mamba, the Bristol Theseus, and the Rolls-Royce Derwent engines have already completed 500-hour bench tests without any major engine failure and with only routine maintenance. As an example of the ease of maintenance, only 15 man-hours were spent on servicing during the Mamba 500-hour test.

As far as the propeller turbine is concerned, this type of power plant will be fitted into very large, relatively low-speed aircraft which will require extremely large power plants. Engines of 3000 h.p. are already well advanced in the design stage, and the Brabazon I and the large Saunders-Roe flying boat will be fitted with pairs of Bristol Proteus 3000-h.p. engines coupled together to drive one pair of counter-rotating airscrews.

The big disadvantage of the propeller-turbine engine compared with the piston engine is still its high fuel consumption. To obtain improvements in this direction, there will certainly be a trend towards higher compression ratios and, in the case of very large engines, heat exchangers will probably be used to recover more energy from the turbine exhaust gases. With such an arrangement the air will leave the compressors, pass through a heat exchanger in the tail-pipe and thence to the combustion chambers. Experimental engines have already been built with heat exchangers, but in the small size of engine to which they have been applied, the extra weight of the heat exchanger was not justified by the improvement in fuel consumption achieved.

There is also the overriding question of turbine blade temperatures, and any metallurgical developments which will allow material increase in turbine entry temperatures will show large dividends in the way of improved thermal efficiency of gas turbines as a whole.

When consideration is given to the improvements and developments taking place in turbine engine design, it will be seen that the design of future aero-turbine engines will have lost the simplicity which was such an attractive feature of the early jet engines. However, it must be remembered that, even with all the devices referred to here, the propeller turbine engine is still far less complicated than a piston engine of comparable h.p. For example, a 3500-h.p. piston engine will have 28 cylinders, 56 valves, 56 sparking plugs, 7 magnetos, not to mention the complicated cooling air arrangements, the constant-speed supercharger, complicated ignition harness, as well as the very intricate automatic carburettor. Looked at in the true perspective, for engines of above 3000 h.p. the gas turbine is still a far simpler proposition than the piston engine and, in fact, for really large engines of over 5000 h.p., and for high-speed aircraft, the gas turbine is the only solution.

PETROLEUM GASES AS AN AID TO FUEL ECONOMY

A further step in the closer integration of British petroleum refining with the general economic and industrial activity of the country was taken on March 16, when a pipeline was opened from the Ellesmere Port (Cheshire) gasworks to the near-by petroleum refinery of Lobitos Oilfields Ltd. This line, nearly a couple of miles in length, serves to feed to the gasworks the surplus gas formed during cracking operations at the petroleum refinery. The amount of gas that it is expected to transfer is about 25,000 cu. ft per day, which will enable the gas undertaking to economize about 2000 tons of coal per annum.

The Hutchinson Instrument Co. has recently issued leaflets and price lists of apparatus for testing asphalt and bitumen.

[Photo by Birmingham Post and Mail

THE STUDENTS DINE

THE second Annual Dinner of the University of Birmingham Chemical Engineering Society and the Student Section of the Institute of Petroleum was held on March 15 at the Midland Hotel, Birmingham. Some ninety students and their guests were in holiday mood and, fortified by an excellent dinner, settled back to hear their principal guests and officers "sing for their supper". This was a unique occasion, for, in addition to the President of the Society, Professor F. H. Garner, himself a past-president of the Institut of Petroleum, the reigning presidents of the Institution of Chemical Engineers, the Institute of Fuel, and the Institute of Petroleum were the guests of honour, and each in his own manner contributed to the success of the evening.

"THE INSTITUTIONS"

Professor Garner, in proposing the toast of the Institutions, set what proved to be the spirit of the entire evening, in a speech which combined humour, erudition, and research. He developed his views that education must include a broad introduction to the humanities as well as training in a particular field. After outlining the history of the Students' Section of the Institute of Petroleum and its connexion with the parent Institute, Professor Garner spoke

[Photo by Birmingham Post and Mail

The Institute of Petroleum was well represented by (left to right) *Dr F. Mortin* (Member of Council), *C. S. Windebank*, *E. J. Dunstan* (Member of Council), *Professor F. H. Garner* (*past-president*), *E. A. Evans* (*president*).

[Photo by Birmingham Post and Mail

(Left to right) *Dr D. T. A. Townend* (Institute of Fuel), *R. W. Grafton* (chairman of the Society), *H. W. Cremer* (Institution of Chemical Engineers), *Professor F. H. Garner* (Dean of the Faculty of Science), *E. A. Evans* (Institute of Petroleum), *Professor Stacey G. Ward* (Birmingham University), *Professor M. L. E. Oliphant* (vice-principal, Birmingham University).

of the increasing field of studies in the Department of Chemical Engineering and stressed the importance to industry and students alike of maintaining adequate contact between student bodies and the professional institutions. He wished to ensure that the universities produced men of both learning and wisdom whose value to the community would lie in their ability to transfer to industry the ideas and findings of academic research.

Mr H. W. Cremer, replying on behalf of the three Institutes, spoke of the desirability of closer working of the three bodies. Whilst each had a particular sphere of activity, they had much in common. Thus far it had not been possible to develop a common effort but he looked forward to the time when joint meetings of the three bodies would be possible.

"The Guests"

Mr M. T. B. Jones then proposed the health of the guests. In addition to the presidents of the three Institutes the guests included representatives of the University (Vice-Principal, Registrar, and Secretary), students from the Chemical Engineering Schools of Glasgow, London, and Manchester universities, representatives of various Midland industries, fuel, coal tar, petroleum, and others. Most of the industrial guests were, as Mr Jones pointed out, personal friends of the students, these friendships having been made during the vacation courses in which the students had opportunities to obtain industrial experience. Presumably this experience included an ability to appraise and bid one's hand, for Mr Jones's reference to bridge in relation to vacation courses met with wide approval.

Mr E. A. Evans, replying on behalf of the guests, introduced into the delightful mixture of humour, biblical quotations, and scientific definitions which we have learned to expect from him, some kindly advice to the student entering into industry, and again stressed the desirability of the student maintaining contact with his university. He expressed on behalf of all the guests the great pleasure it gave them to meet the students and to see what an active and enthusiastic society existed at Birmingham.

"The Society and The Section"

Dr D. T. A. Townend proposed the toast of the "Birmingham University Chemical Engineering Society and the Student Section of the Institute of Petroleum". Again the speech combined humour and anecdote with more serious aspects of university functions. Dr Townend suggested that the provincial university should provide local industry with personnel and that this should be regarded as one of its main functions. Whilst admitting the desirability of studies being broadened to include the humanities, he felt that the demand of local industry for scientific personnel trained to assume leadership was so great that it should take precedence over other needs.

Mr R. W. Grafton, chairman of the Society, thanked Dr Townend and his fellow guests for the honour they had shown the student society by accepting the invitation to be present at the Annual Dinner. He outlined the growth of the Society from the Student Section of the Institute of Petroleum, which until 1947 had been the sole society in the Department of Chemical Engineering. With the growth of the department had come the need to cater for the social and athletic activities of the students and to provide a society capable of supplying the needs of students of coal utilization, fuels, chemical engineering, chemical technology, and petroleum technology. Whilst it was intended to preserve the integrity of the Student Section of the Institute of Petroleum, it would be realized that the wider scope of the "Chemical Engineering Society" of

which the Student Section was an integral part, was fully justified. The diversity of industries represented by the guests present indicated the scope of interest of the student body.

Many anecdotes enlivened the proceedings, the spontaneous account by Dr Townend of his (we presume) beautiful travelling companion and her breathless story of travels from California to Euston—to which he had listened as his contribution to Marshall Aid—was perhaps the outstanding. Mr Evans's definition of information and intelligence is too good to miss—the former produced by dissemination, the latter by insemination. Professor Garner's scurrilous definition of a chemical engineer was listened to with the careful attention it deserved, for it pointed to the many factors which a good chemical engineer would do well to avoid.

One thought which remained after the evening was the great care with which the principal guests had prepared their speeches. That the presidents of the three Institutes, each a busy industrialist carrying a very heavy responsibility, should be prepared to devote their valuable time to come to speak to a student gathering and to do so with such kindliness was very encouraging indeed. It was obviously much appreciated by everyone.

G. R. LLEWELLYN, M.B.E.

G. R. Llewellyn, M.B.E., F.Inst.Pet., relinquished his position as manager of the Fuel Oil Department of Shell-Mex and B.P. Ltd. at the end of last year, but is remaining with the department during 1949 in an advisory capacity.

On March 22 some of the older members of the oil burner industry entertained Mr Llewellyn to a private luncheon at the Waldorf Hotel and presented him with a silver salver suitably engraved.

In making the presentation, W. A. Hubbard referred to the pioneer development work in connexion with oil firing which had taken place during Mr Llewellyn's long term of office with the Fuel Oil Department of Shell-Mex and B.P. Ltd. He stated that the presentation was made as an expression of personal esteem for Mr Llewellyn and gratitude for the development work that he had directed.

In replying, Mr Llewellyn suggested that the function was not only a compliment to him personally, but also to his company. Whilst he agreed that the Fuel Oil Department of Shell-Mex and B.P. Ltd. had a reputation for their pioneer development work, he said that those present were also pioneers. They had taken considerable risks and had devoted much time and capital to the development of oil firing for various fields of application.

He knew full well the various setbacks that the industry had suffered, but felt that they might anticipate a fairly bright future if oil was accepted on its technical merits for those applications where it did possess definite advantages and was not regarded as a direct competitor with coal, our national fuel.

The party entertaining Mr Llewellyn comprised: R. F. Jones (Clyde Fuel Systems Ltd.); R. Sutton (Urquhart's (1926) Ltd.); T. Brown (Swinney Bros. Ltd.); R. Allen (J. Samuel White & Co. Ltd.); R. L. Nash (Combustions Ltd.); O. Meikle (May Oil Burner (England) Ltd.); R. L. Cox (G. N. Haden & Sons Ltd.); A. G. Dobbs (The Wallsend Slipway & Engineering Co. Ltd.); Frank Pillinger (G. C. Pillinger & Co. Ltd.); A. B. S. Laidlaw (Laidlaw Drew & Co. Ltd.); W. A. Hubbard (Hubbard Combustion Ltd.).

Sorbsil brand silica gel is the title of Technical Publication No. 21 of Joseph Crosfield & Sons Ltd., a revised edition of which is available from Lever Brothers & Unilever Ltd., Unilever House, London, E.C.4.

COUNCIL COMMENTARY

THE Council meeting on February 9 opened with the announcement from the President that the death sentence on Dr Papp, the Hungarian oil scientist, on whose behalf we and other learned bodies had petitioned the Hungarian Government, had been commuted to life imprisonment, perhaps only a small mercy but none the less a real one for which we can be grateful.

After the minutes had been passed, the President gave his opinion with regard to the one matter arising, namely, that the question of Institute representation on Ministry of Fuel and Power committees had been well covered by the Right Hon Hugh Gaitskell in his speech on the occasion of the Annual Dinner. This dinner, incidentally a welcome revival and we hope a sign of the times, was a great success. Many senior members of the industry were present, together with several members of the Ministry of Fuel and Power, and a full list was published in the *I. P. Review* (see page 97).

Reports were presented with comments by representatives of the following committees:

Aviation Products Data, Branches, Election, Engineering, Publications, and Research. Miscellaneous items dealt with the draft report of the Institute for 1948, the appointment of scrutineers for ballot papers, the World Petroleum Congress, and even a proposed golf meeting.

There never seems too much time to deal with all the items arising, and the President has an exacting task for 2½ hours each month to get through the agenda.

Matters of recurrent interest just now are finance and membership, not entirely independent matters, which require full council discussion on the separate recommendations of the two committees. Everyone must be gratified by the success which has attended recent efforts to increase membership, corporate personal as well as member companies, but unless correct relation can be established between contribution and receipt, we arrive at the anomalous position that increased membership has the possibility of becoming an embarrassment. During a period when costs of everything have risen, the Institute has actually increased its services to members in the shape of Publications, (e.g., the *I. P. Review*), library facilities, improved accommodation and in other ways, causing severe pressure on the finances, one item of which—membership fees—has not as yet risen at all. It is confidently expected, however, that the situation will be met by increasing realization on the part of companies great and small, who are taking up memberships as companies, and on the part of individual corporate members, that all benefit by having a strong, alert and active Institute which should expand rather than contract its activities, and that we can in the long run only get out of the Institute what we collectively put into it; this means of course increased contributions. Ways and means of bringing this to the notice of all concerned are being actively pursued. The situation affects not merely £. s. d. but effort. The bulk of the material, scientific and general, is contributed on a voluntary basis by members, and each branch and member is reminded of his responsibility to contribute matters of interest for inclusion in the *Journal*, the *I.P. Review*, or other publications.

An excellent example of work of benefit to the whole industry is at present being pursued by the Engineering committee, which with great courage has embarked on the "hazardous" task of compiling a code of safety to deal with the hazards of the industry. Such codes in the form of regulations are never popular, but since some minimum code is essential, it is likely to be more useful and less embarrassing if compiled within

the industry than if imposed from without!

Rules for branches again came in for discussion and as it was realized that rules are made for branches and not branches for rules, it was possible to adapt the model rules to the particular circumstances of the London branch, without departing from the principles or indeed the letter of the by-laws, and it is confidently expected that the same flexibility will be possible with regard to the Birmingham Students' Branch.

The Branches Committee enjoyed the social side of the Northern Branch activities, when they were entertained as guests of the Northern Branch at a very pleasant dinner dance, at which the Lord Mayor and Lady Mayoress of Manchester were present, after their quarterly meeting held in Manchester. Tribute was paid by Mr Thornley. A request was received and approved by the council for the foundation of a new branch at Fawley. Mr T. Dewhurst and Mr Tett intimated their willingness to attend a meeting of the World Petroleum Congress Committee at The Hague. Finally, the secretary was authorized to go ahead and try to arrange an Institute golf meeting in the early summer near London.

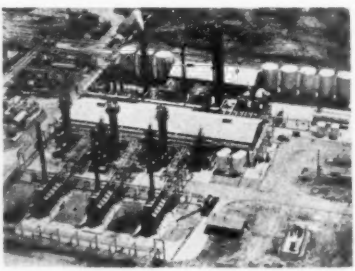
POST-WAR CARS

An excellent attendance of Stanlow Branch members, together with numerous visitors, including many engaged in various branches of the automobile industry, was present at the Grosvenor Hotel, Chester, on February 16, 1949, to hear M. S. Crosthwaite, A.M.I.Mech.E. of the *Automobile Engineer* give his paper entitled "Automobile design: basic problems and current practice". Mr Crosthwaite gave a lively illustrated lecture covering all the major points of motor-car design which affect car performance and road-holding. It is hoped that his paper will appear in a subsequent issue of the *I. P. Review*.

After the usual break for refreshments, at the end of the paper, a very vigorous discussion took place in which as well as asking the lecturer numerous questions, members had the opportunity of expressing their own views on modern car design, several features of which did not meet with unanimous approval. Among the other points arising in the discussion it was of interest to note the considerable attention which many participants paid to the problem of dazzle. The proceedings continued to an hour considerably later than usual for Stanlow Branch meetings and were concluded with a vote of thanks, proposed by V. Biske.

THE LIGHTER SIDE

The Annual Dance of the Stanlow Branch was held on March 17, 1949, at Quaintways Restaurant, Chester, when approximately eighty members and visitors were present. This was the third such function of the branch, all of which have been held in the same venue, the pleasant and intimate informal atmosphere of which provides an excellent setting for what is now becoming a regular feature of the branch's activities.



Part of the new plant for the manufacture of ethyl alcohol from petroleum erected by the Shell Chemical Corporation at Houston, Texas. Costing $12 million, this plant will use as raw material refinery gases from the nearby catalytic cracking unit.

CORRESPONDENCE

"COLLOIDAL FUEL"

To the Editor, *I.P. Review.*

Sir,

In the interesting and informative article by Mr R. A. Acton-Taylor published in your March issue, the author, after outlining the half-century or so of experimental work which has been carried out on colloidal fuel, states that it has never come into use, and the reason for this is not clear. Is not the explanation to be found in the fact that colloidal fuel, or, more correctly, coal/oil mixtures, offer no worth-while advantage to the user? There is a well-established and highly efficient technique for the burning of oil fuel, and the same is true of coal. The user knows what results to expect, and usually obtains them. In the case of coal/oil mixtures, however, as the author so clearly points out, there are many practical difficulties in the way of its manufacture, storage, and burning, which have no exact counterpart when oil and coal are burned separately. A coal/oil mixture is neither a good solid fuel nor a good liquid fuel, and the advantages (if any) which it offers over coal or oil are not clear and convincing to the potential user. For marine boilers the small saving in storage space on board ship is unfortunately more than offset by the difficulties outlined in the article, and for land plants, of course, a small economy in storage space is of negligible value. Plants which might be considered suitable for coal/oil mixtures are usually of a kind which could use pulverized coal equally well, and at lower cost.

The author states that "Colloidal fuel offers a means of eking out valuable supplies of oil by the substitution of coal". The converse is also true. If ever it is necessary to increase the consumption of either coal or oil in this country because the other is in short supply, I suggest that the most satisfactory method would be to burn the additional oil or coal separately in a normal type of plant of proved efficiency, and thus avoid the many pitfalls mentioned by the author.

It is possible, of course, that at some future date a market may be discovered or developed in which a coal/oil mixture will give better all-round results than any other fuel, but at present such a market does not appear to be in sight.

I am, sir,

Yours, etc.,

GEO. R. LLEWELLYN

St. Stephen's Club,
Westminster,
London, S.W.1
March 29, 1949

BOILER FUEL FOR DIESEL OPERATION

The M.S. *Lampania*, a 9000-d.w.-ton Shell tanker, has recently completed twelve months' operation of her diesel engines on boiler fuel. The owners report that her engines have given trouble-free service and that the use of boiler fuel in a vessel of this size effects a reduction of about £10,000 in the annual fuel bill.

Experiments in the use of boiler fuel in diesel engines began in August 1946 with the acceptance trials of the *Auricula*. Exacting tests showed that boiler fuel was not only cheaper to use, but subjected valves and pistons to less wear than normal grades of marine fuel. Only minor alterations to existing engine-room equipment were necessary, in the main consisting of providing fuel purifying plants for extraction of sludge and ash and of fuel heating facilities.

At present Shell has five tankers, totalling 54,767 d.w. tons, operating on boiler fuel and several in course of conversion. It is estimated that if all motor ships on Lloyds Register were converted to use boiler fuel, the annual saving on fuel would amount to more than £70 million.

PETROLEUM IN PARLIAMENT

German Synthetic Plants

The Secretary of State for Foreign Affairs said (March 11) that the production of synthetic petrol and oil in Germany was prohibited. Two plants using the Fischer-Tropsch process were producing primary materials for the manufacture of fatty acids and synthetic detergents for the soap and washing powder industry, and permission had been given for two plants originally erected for the hydrogenation of coal by the Bergius process to be used to a limited extent for the hydrogenation of residues obtained from the initial refining process of imported crude oils and also for the production of synthetic ammonia.

Jet Aircraft Fuel

There has been no difficulty in obtaining supplies of kerosine for jet aircraft of the R.A.F., said the Secretary of State for Air on March 30. The technical and supply questions arising from increased consumption expected in the future are under consideration.

He suggested that the question whether the plans of the oil refining companies were going to keep pace with future kerosine demands should be addressed to the Minister of Fuel and Power.

Bunker Prices

The Minister of Fuel and Power said on March 30 that London prices for coal and oil were 98*s* and 103*s* per ton respectively. On a thermal basis, assuming 4 tons of coal to equal 3 tons of oil, the coal price would have to be 77*s* 3*d* a ton to equal 103*s* for oil.

Burning Oil

On March 31 the Minister of Fuel and Power was asked whether, in view of the poor quality of paraffin, which results in inefficient operation of incubators and brooders and danger to stock from fumes and fires, he would allow petroleum distributors to market better-quality burning oils. The Minister said he was prepared to consider such proposals, provided they caused no serious storage or supply difficulties.

Fuel Oil

It is now possible to supply fuel oil to those firms whose conversion to oil burning, though approved, had to be deferred in December 1947. New applications will be granted only where oil has exceptional economic advantages or alternatives are impracticable, said the Minister of Fuel and Power on March 31.

Opencast Operations

The Minister of Fuel and Power estimated (March 31) that rather less than half a gallon of petrol and about two gallons of diesel oil were consumed per ton of opencast coal excavated.

Leeward Islands

The Secretary of State for the Colonies was asked on April 6 to make a statement on his immediate plans to proceed with underwater oil boring along the coast of the Leeward Islands; what would be the approximate cost over the next five years; and when boring was to commence.

The Under-Secretary replied that the Governor had been asked to consult the director of the British Guiana Geological Survey with regard to taking the necessary steps.

TRINIDAD BRANCH COMMITTEE

At the Annual General Meeting of the Trinidad Branch the following were elected as the committee for 1949: F. C. Hamilton (chairman); J. S. Collcott (hon secretary and treasurer); A. S. Curlett; Dr A. L. Down; P. E. T. O'Connor; H. W. Reid; C. C. Wilson.

U.S. OIL AND GAS RESERVES

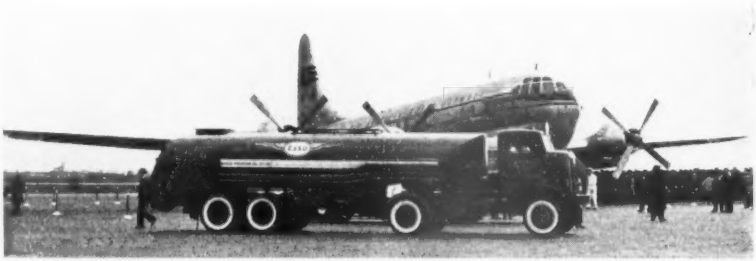
The A.P.I. Committee on Petroleum Reserves has reported that the proved reserves of crude oil in the United States at the end of 1948 amounted to 23,260,444,000 brl, an increase of 1,792,759,000 brl during the year. In addition, the American Gas Association estimates that reserves of natural gas liquids (natural gasoline, condensate, and liquefied petroleum gases) at that time totalled 3,540,783,000 brl, an increase of 286,808,000 brl over 1947. Thus total liquid hydrocarbon reserves in the U.S.A. at the end of 1948 are estimated at 26,821,227,000 brl. Details are given in the accompanying table.

	Crude Oil		Natural gas liquids		Total liquid hydrocarbons	
	In thousand barrels					
Total proved reserves 31.12.47		21,487,685		3,253,975		24,741,660
Revision of previous estimates	1,958,853		405,874		3,804,600	
Extension of old pools	1,439,873					
New reserves found in 1948	396,481	3,795,207	64,683	470,557	461,164	4,265,764
		25,282,892		3,724,532		29,007,424
Less production in 1948*		2,022,448		183,749		2,186,197
Total proved reserves 31.12.48		23,260,444		3,540,783		26,821,227

* Based on eleven months' production plus an estimate for December.

MASS SPECTROGRAPHY

A bibliography on the mass spectrometer from January 1938 to December 1948, prepared by the Intelligence and Interchange Section, Research Department, of the Metropolitan-Vickers Electrical Co. Ltd., is available for consultation in the library. There are 421 references grouped under Instrument design (99 refs.); Operating techniques (52); Applications to isotopic problems (144); Application to organic chemistry (39); Ionization and dissociation of molecules (49); General applications in engineering and physics (38).



When the Pan-American Boeing Strata Cruiser Flying Cloud *reached London Airport on April 4 it was fuelled with the new grade of 115/145 aviation spirit. Its fuel load is 6000 Imperial gallons.*

LIQUID PARAFFIN

Some medical and legal aspects of its uses and abuses

By V. BISKE, LL.B. (Fellow) and EVELYN M. BISKE, M.R.C.S., L.R.C.P.

". . . and oil to make him a cheerful countenance . . ."
—*Psalm* civ, 15.

HISTORICAL

Medicinal uses of petroleum and its products can be traced very far back into history. Whilst the greater number of such purposes for which mineral oil was first utilized concerned external application to the body, the internal consumption of petroleum has also been practised for a long time. It is not proposed in this discussion to pursue the earlier history of the therapeutic use of petroleum but to consider merely the modern use of refined mineral oils for laxative and other internal purposes.

According to a report made to the American Medical Association,[1] internal use of refined petroleum oil was suggested in a patent granted to Chesebrough in 1872, whilst specific reference to the laxative properties of heavy refined mineral oil appears to date from 1885. Even then it was recognized that such oil had no food value and it was considered that it was not absorbed by the body.

In Great Britain, liquid paraffin was first included by the British Pharmacopoeia in its 1898 edition, where specific gravity limits of 0·885 to 0·890 were laid down, together with a stipulation that the boiling-point should be not less than 360° C. Already at that date a sulphuric acid test for purity was required. In the 1914 edition of the B.P. the gravity limits were widened to 0·860 to 0·890 and the boiling-point clause withdrawn, but it was not till 1932 that a viscosity requirement was introduced. The present edition (1948) of the B.P. lays down stringent tests to ensure the purity of the material, which is officially designated as Paraffinum Liquidum, abbreviated as Paraff. Liq., the English equivalent of the official Latin name being Liquid Paraffin. Two grades are stipulated, the lighter variety having the designation Leve (abbreviated to Lev) or Light added. The requirements as to purity of the two grades are similar; the heavier oil has a minimum viscosity of 64 cs at 37·8° C as against a maximum viscosity of 33·1 cs at the same temperature for the light product, whilst the respective density limits (at 20° C) are 0·865 to 0·890 and 0·830 to 0·870. As well as being one of the standard temperatures at which the viscosity of petroleum products is normally determined, 37·8° C (100° F) has the advantage, for a medicinal product, of being a close approximation to normal body temperature; in other words, the viscosity of the material is determined at its operating temperature.

In the early years of the century, the main criterion in most pharmacopoeias by which medicinal oils were judged was the specific gravity. There would appear to have been considerable divergence of opinion as to what was the optimum figure, the permissible range varying from 0·840 (Spanish pharmacopoeia of 1905) to 0·945 (Japanese pharmacopoeia of 1906).

The general use of heavy refined white mineral oils for internal application as a laxative appears to date from the years immediately preceding World War I; the oils recommended at this period were almost exclusively of Russian origin. In the U.K. the use of mineral oils in the treatment of abdominal conditions was greatly encouraged by the views of Arbuthnot Lane; apart from its purely aperient uses he also considered it suitable as one of the measures in the non-surgical treatment of chronic intestinal stasis.[2]

As a consequence of the almost total eclipse of the Russian petroleum industry during and immediately following the 1914–18 conflict, manufacturers turned to other sources of supply for the distillates required for its manufacture and its production in America from both indigenous and imported (e.g., Peruvian)[3] oils was greatly increased. The popularity of liquid paraffin both as a medicine prescribed by physicians and as an article for self-medication increased steadily in the inter-war period, and it can now be considered as being firmly established as one of the more widely used laxatives.

In the earlier literature of the subject considerable importance was attached to the source of the mineral oil and Russian oils were considered superior to most others. The statement was frequently made that there was a marked difference between the chemical constitution of Russian oils, which were viewed as largely consisting of naphthenes, and American (Pennsylvanian) oils which were predominantly paraffinic. Whilst, of course, there is a certain amount of truth in this differentiation between the preponderant hydrocarbon groups present in the different crudes, the drastic refining treatment to which medicinal oils have to be subjected in order to enable them to meet the requirements of the more stringent modern pharmacopoeias (such as B.P. 1948 and U.S.P. XIII) would tend to even out variations between the base stocks and, in the case of finished oils, meeting present-day specifications, it is unlikely that the differences still remaining in hydrocarbon composition can have any appreciable effect on their medicinal action.

Despite this, however, criticism can be levelled at many of the workers who have investigated the biological effects of liquid paraffin, since they have not always clearly specified the material with which they have been working. Whilst it must be assumed that mineral oils used in experiments involving their being taken internally by either human or animal subjects have been of pharmaceutical quality and complying with the current requirements of the national pharmacopoeia applicable, it would have eliminated any doubt if this had been categorically stated in all cases. Moreover, it is suggested that, in all work of this nature, the extra trouble involved in determining and reporting the principal identifying tests on the oil used would be well worth while, as adding to the completeness of the record.

Pharmacology

The mode of action of liquid paraffin in assisting the evacuation of the bowels is purely mechanical. Most other laxatives function either by stimulating peristalsis (e.g., cascara), by irritating the intestine (e.g., croton oil), or by exerting an osmotic effect, whereby they increase the bulk of the faeces and thus stimulate evacuation (e.g., Epsom salts). Medicinal paraffin acts almost entirely as a mechanical lubricant, softening the faeces and thus rendering the emptying of the rectum easier. There is also the view that, to some extent at least, mineral oil forms a water-retaining emulsion[4] which leads to bulkier stools, thus helping their elimination.

Objections Raised to the Use of Liquid Paraffin

When medicinal paraffin was first introduced it was viewed as being a completely inert material, and was welcomed as a laxative agent which was absolutely harmless and which could be taken in large and regular doses with impunity. Recently, however, this material has come under a considerable fire of criticism both in its use as a medicine and also in connexion with its increasing utilization as a food ingredient.

A considerable amount of investigation in this field has been carried out during the last twenty years; in the result

it would appear that whilst medicinal oils should be considered as a valuable remedy for certain conditions, their abuse by indiscriminate and uncritical over-use should be guarded against. In this they are no different from any other popular medicine, where judicious application with a knowledge of the factors involved is beneficial whilst excess is harmful.

To take first the bogy of carcinogenicity. The fact that numerous hydrocarbons have been shown to have carcinogenetic properties has resulted in suspicion being cast on any hydrocarbon material taken internally as being a possible source of malignant growths. The original view that mineral oils are not absorbed from the intestine has now been amended and there is no doubt that a certain amount of such absorption does in fact take place. Absorption can be determined in two ways, by an examination of the faeces for the presence of mineral oil, which frequently shows almost complete recovery as compared with the amount ingested; this led the earlier workers in this field to the view that mineral oils were not absorbed, since small differences between the amount taken and that recovered were ascribed to experimental error. The alternative is to examine the tissues concerned for the presence of mineral oil; in such cases the detection of traces is easier and absorption of the oil can be proved.

Channon and Collinson[5] examined the unsaponifiable fraction of the liver fat of pigs in whose diet liquid paraffin had been incorporated; a comparison of the iodine values of the oils of animals on normal and on test diets indicated that a certain amount of mineral oil was stored in the liver. Evidence of absorption was also obtained by Twort and Twort.[6]

An extensive series of experiments was carried out by Stryker;[7] changes were detected in the mesenteric lymph nodes of experimental animals and similar changes were also seen in necropsies on human subjects. However, this investigator draws the conclusion that, although there is absorption of mineral oil, there is no proof of any harmful pathological effects.

There is some evidence, moreover, that even the small amounts of mineral oil that are absorbed can be, to a certain extent at least, metabolized with the formation of fatty acids. In work carried out with tetradeutero-hexadecane, Stetten[8] showed that 15 per cent of the deuterium could be identified in fatty acids found in the liver after the hydrocarbon had been fed to rats.

The absorption of liquid paraffin is considerably affected by the physical state in which it is present in the bowel. If the particles of oil are small, as in an emulsion, absorption is greatly facilitated, and the researches of Frazer and his colleagues[9] show that a particle size of less than 0·5μ gives rise to considerable absorption, which can be as high as 60 per cent of the amount of mineral oil taken.[10]

The work of Frazer indicates that whilst fats can be emulsified in the bowel by the action of natural emulsifying agents there present, mineral oils are not usually emulsified in these conditions and that, therefore, they are only absorbed to an appreciable extent if they are originally ingested in emulsified form. However, there is a possibility that a certain amount of emulsification may occur (presumably by the aid of the bile salts) after ingestion.[11]

Nevertheless, none of the workers who have studied the absorption of mineral oils from the intestine have found any definite evidence of resultant tumour formation, and in an official report of the American Medical Association made in 1943[12] it is stated that "It appears however that there is no real basis for the belief that mineral oil has any carcinogenic effect." (The "mineral oil" refers here, of course, to liquid paraffin.)

Apart from the risk of carcinogenicity, which would appear to be non-existent, the other main objection that has been raised to the use of liquid paraffin as a laxative is that it interferes with the absorption of vitamins. In this case the evidence is considerably stronger, and there would seem to be little doubt that mineral oil, if taken internally in excessive quantities or at unsuitable times, can adversely affect the utilization by the body of accessory food factors. The vitamins concerned are those which are fat-soluble, namely A, D and K, and the effect is a physical one; the solubility of these materials in hydrocarbons being considerable they tend to be retained in the mineral oil phase, if this is present, together with the vitamin-containing food.

The most serious interference with food absorption seems to be in the case of carotene. A large proportion of the vitamin A requirements of the human subject is met by this pro-vitamin; in the U.S.A. about 60 per cent of the vitamin A requirements are provided by carotene. It has been shown by Alexander *et al.*,[13] that the plasma carotene level is decreased if mineral oil is taken at meal time, although the vitamin A level is not significantly affected. Vitamin K which is concerned with the blood-clotting mechanism can also be preferentially retained by mineral oil; this factor can be of significance in the case of pregnant women, who frequently take large quantities of medicinal paraffin as a laxative and in whose case a high vitamin level, particularly vitamin K to control post-partum hæmorrhage, is desirable. However, vitamin and pro-vitamin loss due to mineral oil occurs principally if the liquid paraffin is taken at a time when food is in the stomach; if the time of dosage is chosen so that any food present has been digested there is little danger of any appreciable vitamin loss occurring.

Other objections to the medicinal use of mineral oil that have been made are largely confined to over-liberal indulgence in this remedy. If excessive quantities are taken (the dose recommended by the B.P. 1948 is 8 to 30 ml compared with the 1914 figure of 4 to 16 ml) there is a risk of anal seepage; too much also tends to defeat its own object since unduly soft stools fail to stimulate peristalsis.[14]

Morgan[15] states that surgical examination is interfered with if the wall of the rectum is coated with a film of hydrocarbon oil, but this is hardly an objection that applies to normal cases, whilst Zahorsky's[16] view that the use of liquid paraffin leads to colitis does not seem to have been confirmed by other workers. In fact liquid paraffin has been recommended in the treatment of this condition.[17] Morgan likewise raises the objection that the use of liquid paraffin is an interference with the normal physiological functioning of the bowel and rectum; this argument is equally applicable of course to any form of remedy whatsoever; it is merely because some interference with natural functioning has already occurred that liquid paraffin (or any other laxative) is required. He likewise puts forward the view that, by speeding up the mobility of the contents of the small intestine, digestion is hampered. If this were the case, then analyses of the faeces of subjects using liquid paraffin would show a higher proportion of undigested matter than in normal subjects, and the writers are not aware that such findings have been reported.

When Liquid Paraffin Should Be Used

(*a*) *Internally by mouth*

The clinical indications for the use of liquid paraffin are principally in cases where any straining during defaecation is highly undesirable, such as hæmorrhoids, and in patients who are convalescing from operations involving

surgery of the rectum. In such conditions liquid paraffin is the ideal laxative and is invaluable. It is also a valuable adjunct in pregnancy when the use of the vegetable laxatives (e.g., rhubarb, senna) which stimulate peristalsis is undesirable, since they can also act on uterine muscle.

In ordinary cases of constipation, liquid paraffin can be used in moderation, but its daily consumption as a habit by the normal subject is to be deprecated, as indeed is the daily use of any stimulant of what should be a natural function.

In all cases where liquid paraffin is used it is preferable that it should be taken some hours after a meal and well before the next, so that is not present in the stomach together with food.[18] Thus, obviously, the best time is immediately before retiring for the night. To minimize absorption, the use of the clear oil, rather than a paraffin-containing emulsion, is to be preferred.

A use of liquid paraffin which may be mentioned, although hardly recommended, is its ingestion in fairly large doses prior to any occasion on which considerable quantities of alcoholic liquor are to be consumed. By forming a hydrocarbon oil film on the walls of the stomach and intestine the absorption of alcohol into the bloodstream is greatly retarded, with the consequence that surprisingly large amounts of intoxicating liquor can be consumed without their usual effects becoming apparent till considerably later than is normally the case. The view that such a protective film mechanism is in fact responsible for this effect receives confirmation from the work of Driver[19] on the coating of internal membranes with an oil film, and the consequent inhibition of the digestive action of a 0·1 per cent pepsin solution in N 10 hydrochloric acid.

The use of olive oil for a similar "anti-alcoholic" purpose has long been known but this, being a fatty oil, only exerts its effect till it has been digested or absorbed, whereas liquid paraffin, not being broken down by the digestive juices or absorbed to any appreciable extent retains its efficacy for a longer period.

(b) Other medicinal uses

Apart from its principal use as a laxative, liquid paraffin is also employed in the preparation of various nasal sprays and in ointments. For use in sprays the light liquid paraffin is usually preferred. Objections to its use have been raised on the ground that if allowed to enter the lungs such sprays can lead to lipoid pneumonia. This is not a common condition, but can occur in children, and in old and weakly persons where the normal reflexes against the penetration of liquids into the lungs are not functioning adequately. However, in such cases lipoid pneumonia is not a prerogative of liquid paraffin but can also be caused by milk fat and cod-liver oil.[20] As an extreme case of such oil-aspiration pneumonia may be mentioned the inflammation found in cases of torpedoed seamen into whose lungs sea-water contaminated with fuel oil has entered.

Use of Liquid Paraffin in Foods

Whilst the use of refined mineral oils in foods has been suggested at various times in the past[21] the subject has come into considerable prominence in recent years due to the present shortage of natural fats (glycerides). Even before such shortage arose, use of mineral oil in foods was being made to an appreciable extent in the U.S.A., largely in salad dressings. Possibly the greater consumption of salads by the American public, together with, perhaps, a greater tolerance of unorthodox diets in that country, led to mineral-oil base foods finding some popularity. The craze for "slimming" was a factor in the sale of such preparations, which were widely advertised as "non-fattening" or "slenderizing". Whilst mineral oils had been

earlier used as adulterants (e.g., in fish-preserving oils)[22] and for subsidiary uses, such as the coating of raisin and coffee beans to prevent loss of volatile essential oils, it was not till the 'thirties that they came into prominence as food constituents to any marked extent. The question of mineral-oil containing food was considered by the American Medical Association on several occasions,[23] numerous proprietary brands of U.S. foods containing mineral oil being mentioned. From the producer's point of view such foods (apart from questions of lesser cost) have the advantages of not developing rancidity, and of allowing prolonged storage without the use of refrigeration. However the big disadvantage of such foods is that the mineral oil is ingested together with the food, and hence the vitamin-loss effect mentioned previously is at its maximum. Morever, the use of a salad cream incorporating mineral oil is particularly undesirable, since salads provide a considerable proportion of the carotene requirements in the diet, and it is thus especially unfortunate that they should be consumed in such close association with mineral oil.

For such reasons the Council of the American Medical Association withdrew the limited approval of such foods which they had earlier given and recommended that, if clinical conditions led a physician to recommend their use, this should be on an individual basis and not by overall approval.

A further complication arises if mineral oils are used in foods that have to be cooked. Whilst, as stated above, mineral oils of pharmaceutical quality have been cleared of any charges of causing malignant growths this does not necessarily apply to their decomposition products. Although biological examination of the breakdown products formed by heating medicinal oils to the temperatures used in cooking has shown no evidence of any dangerous effects occurring,[24] the possibility of such effects cannot be entirely excluded and it is undesirable that mineral oils should be used as a substitute for cooking fats.

Such use on a domestic scale has however become fairly common in recent years in the U.K., despite its illegality; presumably it is only an ephemeral phenomenon till fats are again plentiful but, even as a temporary measure, such a course cannot, on purely physiological grounds, be recommended.

Considerable attention has recently been paid to the use of liquid paraffin in baking, and several communications on this subject have appeared.[25] Whilst, of course, the oil is not used commercially as an ingredient of the baked material, small amounts may find their way into the finished product either from the lubrication of baking machinery or from the use of mineral oil as a tin-greasing agent. The recommendation made by the British Baking Industries' Research Association is that the quantity of mineral oil (which should be of B.P. quality) in the bread or other product should not exceed 2000 p.p.m. and it has been stated that most of the bread baked in the U.K. contains less than this amount.

It may be remarked that, provided the oil used is of B.P. quality, the maximum amount recommended as permissible, is if anything, on the conservative side. If it is assumed that a person were to eat 2 lb of bread per day (a quantity considerably in excess of the average consumption) then if this were to contain the maximum amount of mineral oil suggested as permissible, the daily intake would be less than a quarter of the minimum dose of liquid paraffin given in the B.P.

Mineral oils had been used abroad, in baking, before the war[26] and a warning on this subject had already been issued through the German Ministry of Health in 1894.[27] Even during the last war its use as a baking oil was considered undesirable in Holland.[28]

The Legal Aspect

Leaving aside, for the moment, consideration of emergency legislation there is no express prohibition, in the U.K., of the use of mineral oil in foods. The position would however be governed, both in normal times and at present, by the Food and Drugs Act, 1938, the relevant sections being 1 and 3.

By s.1 it is an offence to add any substance to any food so as to render the food injurious to health, with the intent that the food shall be sold in that state. It is also made an offence to sell or have in one's possession for sale any food to which any substance has been so added. If, therefore, reliance were to be placed on this section it would be necessary to prove that the addition of mineral oil to a food had rendered that food injurious to health. Whilst, in view of what has previously been stated regarding the physiological action of liquid paraffin when ingested, especially together with food, a case could be made out, it would not by any means be free from doubt, and the issue would depend almost entirely on the view taken by the court of the scientific evidence put forward. It should be noted that, if the food is proved to be injurious to the health of any class of person, that is sufficient to create an offence under this section; it need not be injurious to the health of all persons.[29]

Apart from a prosecution under the Food and Drugs Act, 1938, there are two other possible legal courses that would be open to the prosecution in such a case. Firstly, it is a misdemeanour at common law to add an unwholesome ingredient to food,[30] and secondly, a person doing so and selling the food can be proceeded against for obtaining money by false pretences.[31]

However, the section of the Food and Drugs Act, 1938, which is more often invoked in cases of this kind is s.3 which states that it is an offence for a person to sell to the prejudice of the purchaser any food which is not of the nature or not of the substance or not of the quality of the food demanded by the purchaser.

It has been held on numerous occasions that the purchaser is not prejudiced if the nature of the material he is purchasing is clearly made known to him either by label or otherwise. If, however, this be not the case it is important to note that actual prejudice or damage need not be proved to convict of an offence under this section.

If there is a food standard in existence[32] then, when a person asks for that particular food, he is deemed to be asking for food of that standard; if there is no standard laid down then, whether or not the food is adulterated so as to be to the prejudice of the purchaser is a matter to be decided by the court in the individual case on the basis of the analytical evidence submitted.

Quite apart from the emergency legislation, to be discussed below, it is almost certain that a court would hold that the presence of mineral oil in a foodstuff, unless declared in unequivocal terms, would be an offence under s.3. In a recent prosecution for the use of mineral oil in the manufacture of pastry[33] it would appear, from the brief report available, that the proceedings were brought under this section.

Even were the inclusion of liquid paraffin declared, a prosecution under s.1 of the Food and Drugs Act, 1938, would still be a possibility,[29] although the presence of a clear warning of the limitations on the use of the food due to such admixture might be a defence.

Emergency legislation

The use of liquid paraffin is at present governed by the Control of Petroleum Order, 1944 (S.R. & O. 1944, No. 171) (as amended by the Control of Petroleum (Amendment) Order (S.I. 1948, No. 1420)), the relevant portion of which is part III, which reads as follows:

"10. *No person shall, except for medicinal purposes or under the authority of a*

licence, treat or use any liquid paraffin or cause or allow any liquid paraffin to be treated or used.

"11. *No person shall, except for medicinal purposes or under the authority of a licence, blend any liquid paraffin with any other petroleum or with any other substance whatsoever or cause or allow any liquid paraffin to be so blended.*"

The terms used in the above paragraphs are defined as follows:—

"'*licence*' *means a licence granted by the Minister.*

'*liquid paraffin*' *means liquid paraffin which conforms with the specification therefor in the British Pharmacopoeia* (*Edition* 1932). '*Medicinal purposes*' *means the relief of human ailments or diseases.* '*the Minister*' *means the Minister of Fuel and Power.*"

It is interesting to note that the Order specifies the 1932 edition of the B.P.; it would thus appear that a liquid paraffin which complies with the 1948 B.P. but not with the 1932 requirements is not covered by the Order. The production of such an oil is technically feasible by selecting a density towards the lower limit of the 1948 range. Moreover, light liquid paraffin, which is the subject of a separate monograph in the B.P., is apparently outside the scope of the Order, although it was introduced into the 1932 B.P. by the 4th (1941) amendment. This oil is, of course, owing to its lower viscosity, less suitable as a fat substitute than is liquid paraffin.

Apart from these possible loopholes (which could well almost nullify the effect of the Order) it is seen that this Order completely prohibits, except under licence, any use of liquid paraffin in the preparation of ordinary foodstuffs. In view of the fact that such use is strongly deprecated officially[34] it seems hardly likely that licences for such a purpose would be granted.

It is thus seen that, by the clear words of the Order quoted above, even the housewife who prepares pastry with the aid of liquid paraffin is undoubtedly committing an offence, since she would be blending it with another substance (i.e., the flour, etc). It is however to be noted that the Order allows such blending "for medicinal purposes". Thus a possible defence to a prosecution would be that, in view of the recognized non-fattening properties of liquid paraffin, cakes, etc., made with it were being employed as components of a special diet, i.e., for medicinal purposes. It is to be noted that the Order defines medicinal purposes as the relief of ailments or diseases, thus whilst it might be debatable whether obesity is a disease, it is probably an ailment.[35] We are thus led to the conclusion that, whilst the domestic use of liquid paraffin in cooking is an offence in the majority of cases, a plausible defence could be put forward if a member of the family concerned could be shown, by acceptable medical standards, to be overweight! A case could perhaps also be made for the view that pastry made with liquid paraffin was merely a suitable medium for taking an otherwise unpalatable laxative.

However, such defences would, possibly, only avail the private domestic user. If a manufacturer were to endeavour to bring his activities within such an argument he would be faced with the difficulty that he would have to declare the composition of his food (so as to avoid offending against s.3 of the Food and Drugs Act, 1938.)[36] If he were to announce that the product he was making (e.g., salad cream) was for the cure of obesity, or a laxative, he might be in difficulties with the Pharmacy and Medicines Act, 1941 (which restricts the sale of a substance recommended as a medicine to the class of persons specified by the Act).[37] It would perhaps be possible for him to plead that, whilst the material in question was medicinal in character, and was being sold with a view to its use in the prevention of an ailment it was intended that the substance be used as a food or drink and

not as a medicine.[38] In such a case the Pharmacy and Medicines Act, 1941, would not apply, and it might be possible to steer a course outside the scope of that Act, and yet within the scope of a "medicinal purpose" within the meaning of the Control of Petroleum Order, 1944.

Conclusions

From a consideration of the evidence which has been briefly reviewed above it may be said that liquid paraffin is a valuable medicament which has a well deserved place in the pharmacopoeia. In the treatment of certain types of abdominal conditions it is almost essential, in many others it is highly suitable, and compares favourably with the alternatives available.

Like any other medicine it should not be taken to excess and regular daily dosage is only desirable under medical advice. Use of liquid paraffin as a major ingredient of foods is (apart from any legal considerations) to be generally deprecated on physiological grounds; its employment in certain special foods may be considered suitable if such foods are recommended medically for the individual concerned. In such cases the food ceases to be a normal product, and becomes a component of a special diet.

Liquid paraffin is a suitable lubricant for food-handling machinery and, where required, for food containers, since the small amounts thus finding their way into food are innocuous.

Since the above was written, The Mineral Oil in Food Order, 1949 (S.I. 1949, No. 614), has been made. This completely prohibits the use of any *hydrocarbon product (of mineral origin) in any food that is sold or intended for sale for human consumption. The presence of up to 0·2 per cent by weight of mineral oil, arising from its use as a lubricant on surfaces with which the food comes into contact during its preparation, is, however, permitted.*

References and Notes

(1) *J. Am. Med. Assoc.*, 1914, **62**, 1740.
(2) *Brit. Med. J.*, 1913, ii, 1125.
(3) Archibald, "The Science of Petroleum", London, 1938, p. 2838.
(4) Logan, *Hygeia*, 1942, **20**, 20.
(5) *Biochem. J.*, 1929, **23**, 676.
(6) *Lancet*, 1932, i, 448.
(7) *Arch. Path.*, 1941, **31**, 670.
(8) *J. Biol. Chem.*, 1943, **147**, 327.
(9) *J. Physiol.*, 1944, **103**, 306.
(10) Frazer, *et al.*, *Nature*, 1942, **149**, 167.
(11) Alvarez, *Gastroenterology*, 1947, 9, 315.
(12) *J. Am. Med. Assoc.*, 1943, **123**, 967.
(13) *Proc. Soc. Exper. Biol. Med.*, 1947, **65**, 275; cf. Mahle and Patton, *Gastroenterology*, 1947, **9**, 44.
(14) Hale-White, "Materia Medica", 27th edn, London, 1947, p. 82.
(15) *J. Am. Med. Assoc.*, 1941, **117**, 1335.
(16) *Arch. Ped.*, 1943, **60**, 250.
(17) B.P. Codex, 1934.
(18) *Lancet*, 1939, i, 461.
(19) *Am. J. Digestive Diseases*, 1945, **12**, 395.
(20) Coope, "Diseases of the Chest", 2nd edn, Edinburgh, 1948, p. 245.
(21) e.g., Ellis, U.S.P. 1,417,893; 2,054,072.
(22) Pyhälä, *Mats. Grasses*, 1936, **28**, 10848 et seq.
(23) *J. Am. Med. Assoc.*, 1937, **109**, 1814; 1943, **123**, 967,973; 1947, **135**, 512.
(24) *Brit. Med. J.*, 1948, i, 1141.
(25) Coppock *et al.*, *Brit. Med. J.*, 1948, ii, 401; 1949, i, 73; cf. *Chem. and Ind.*, 1949, 90.
(26) Grossfeld, *Z. untersuch. Lebensmitt.*, 1937, **74**, 284.
(27) *Fettchem. Umschau*, 1934, **41**, 228.
(28) de Boer and Bosgra, *Pharm. Weekblad*, 1942, **79**, 65; *C.A.* 1943, 3518.
(29) *Haigh* v. *Aerated Bread Co. Ltd.* [1916], 1 K.B.878, where the addition of boric acid to cream was held injurious, although it was only so to children and delicate persons and the fact that the cream contained a preservative was made known to the purchaser. (Following *Cullen* v. *McNair* (1908), 99 L.T. 358.)
(30) *R.* v. *Dixon* (1814), 3 M. & S. 11 (addition of alum to bread).
(31) *R.* v. *Foster* (1877), 2 Q.B.D. 301, although in such a case it is necessary to prove guilty knowledge on the part of the seller.
(32) e.g. in the case of salad cream a standard is laid down by the Food Standards (Salad Cream and Mayonnaise) Order, 1945 (S.R. & O. 1945, No. 1177), which, however, excludes products which are clearly labelled as not complying with the order.

(33) *Manchester Guardian*, December 4, 1948.
(34) Ministry of Food Press Notice 3770A of August 18, 1945, warning food manufacturers against the use of mineral oil as a food ingredient.
(35) The distinction between diseases and ailments was considered in *Nairne and Nairne* v. *S. Smith & Co. and the Pharmaceutical Society of Great Britain*, [1942], 2 All E.R., 510.
(36) and (probably) also to comply with s. 11 of the Pharmacy and Medicines Act, 1941.
(37) For a consideration of a "substance recommended as a medicine" see *Potter and Clarke Ltd.* v. *Pharmaceutical Society of Great Britain* (1947), 63 T.L.R. 309.
(38) Pharmacy and Medicines Act, 1941, s. 17 (1); see also *Nairne's* case (supra).

PROPOSED NEW OIL DOCK ON MANCHESTER SHIP CANAL

The Manchester Ship Canal Co. is proposing to build a new oil dock at the western end of the Canal at Eastham, in order to provide additional discharge facilities to meet increasing refining activity in the area. The new dock, a photograph of part of a model of which is shown here, is designed to accommodate tankers of 28,000 to 30,000 tons with a 34-foot draught, will occupy an area of 75,000 sq. yds and will have an entrance lock 800 ft long by 100 ft wide.

Estimated cost of the whole works is £4 million, and construction is expected to take three years. The necessary Parliamentary Bill has had its second reading and is expected to go before a Select Committee of the House of Lords.

PERSONAL NOTES

Dr Gustav Egloff, F.Inst.Pet., has been nominated for president of the Western Society of Engineers for 1949–50.

Orville Harden, vice-president and director of Standard Oil Co. (New Jersey), has been awarded the Order of Commander of the Legion of Honour in recognition of his co-operation with the French Government in the field of petroleum.

E. J. Dunstan, F.Inst.Pet., has been elected chairman of the North-western Branch of the Institution of Chemical Engineers.

Dr R. P. Linstead, director of the Chemical Research Laboratory, Teddington, is to succeed Sir Ian Heilbron as professor of organic chemistry and director of the Organic Chemistry Laboratories at the Imperial College.

Dr G. B. B. M. Sutherland has been elected to the fellowship of the Royal Society for his experimental researches on infra-red and Raman spectroscopy, especially of hydrocarbons.

N. C. Fraser, M.Inst.Pet., has been elected vice-chairman of the British Chemical Plant Manufacturers' Association for the year 1949–50.

UNIVERSAL OIL MEASUREMENT TABLES

The discussions which took place in London last year between A.S.T.M. and I.P. representatives led to the decision to produce a series of oil measurement tables in the joint names of the two organizations and matters have been proceeding smoothly in the intervening twelve months. A series of thirty-seven tables in all, covering the British, U.S.A., and metric systems, has been agreed, and the work which is to be shared equally between the two bodies will commence very shortly.

When Messrs L. C. Burroughs and J. G. Detwiler of the A.S.T.M. were on this side of the Atlantic they took the opportunity of visiting Europe in conjunction with Mr H. Hyams, chairman of our Oil Measurement Standardization Committee, to discuss in Paris certain aspects of the computation of the tables in the metric system. At this meeting representatives of France, Belgium and Holland were present, and decisions were taken on a few points of principle. It was, however, agreed that when further progress had been made in the preparation of basic data and A.S.T.M. I.P. were ready to present specimen tables in the metric system, a further meeting should be called to which as many interested bodies as possible were to be invited.

The ground has now been sufficiently cleared and prepared for this second conference, and it has been decided that it shall take place in Brussels on June 8 and 9 next. The Société Belge pour l'Etude du Pétrole have agreed to act as hosts, and official invitations have been sent by the Institute of Petroleum to petroleum standardizing bodies in France, Belgium, Holland, Norway, Sweden, Denmark, Switzerland, Italy, Spain, Portugal, and Western Germany for representation at the conference. A number of representatives of the I.P. Oil Measurement Committee under the leadership of Mr H. Hyams and supported by Mr H. R. Holmes, the chairman of the I.P. Tables Panel, will constitute the I.P. delegation.

The A.S.T.M. has agreed that the Institute of Petroleum should act on behalf of both bodies and documents covering the subjects to be discussed will be distributed to the participating delegates in advance of the meeting. It is confidently expected that all outstanding details will be cleared and the ground prepared for "full speed ahead" in the preparation of the full manual of petroleum tables for universal use.

GEORGE N. WILSON

The retirement at the end of March is announced of George N. Wilson, F.Inst.Pet., from the board of directors of Shell-Mex and B.P. Ltd. A prominent member of the petroleum distributive industry in the U.K., Mr Wilson has been connected with the oil industry, and many of its associated interests, since he joined the Asiatic Petroleum Company in 1910 and, in the following year, one of the Shell group of companies in the Far East. He served for some years in Japan and China, and was elected a member of the Council of the International Settlement of Shanghai. He became acting general manager for his company in North China. In 1925 he was recalled to London to become assistant general manager of Shell-Mex Ltd., and was appointed deputy general manager of Shell-Mex and B.P. Ltd. in 1933. He was appointed a director of Shell-Mex and B.P. Ltd. in 1945.

With the formation of the Petroleum Board, Mr Wilson became the Co-ordinator of Fuel and Lubricating Oils for Aviation and was appointed by the Air Ministry as their Honorary Adviser on the Storage and Distribution of Aviation Fuels and Lubricants, in which capacity he assumed a major responsibility for ensuring the prodigious needs of the R.A.F. were at all times fulfilled.

In 1945 he became a member of the Management Committee of the Petroleum Board.

CANADIAN OIL PRODUCTION

Total production of crude oil in Canada during 1946 amounted to 7,586,166 barrels, a decrease of 11·4 per cent from the 1945 figure of 8,558,450 barrels. Total value is given in the official report* as $14,989,052, an increase of nearly 10 per cent over the 1945 total of $13,632,248. Details of production are:

CANADA: CRUDE OIL PRODUCTION

	Barrels	
Alberta:	1946	1945
Turner Valley	6,371,572	7,422,061
Conrad	212,645	143,696
Taber	206,925	135,000
Princess	64,953	63,377
Wainwright	15,114	16,472
Vermilion	183,946	238,358
Lloydminster	76,187	28,321
Other fields	7,190	8,155
	7,138,532	8,055,440
Northwest Territories	177,282	345,171
Saskatchewan	118,686	14,374
Ontario	123,082	113,325
New Brunswick	28,584	30,140
Total	7,586,166	8,558,450

The production of natural gas in 1946 amounted to 47,900,484 m. cu. ft. a slight decrease from the 1945 total of 48,411,585 m. cu. ft. Alberta was the principal source, as shown in the following table:

CANADA: NATURAL GAS OUTPUT

	Million cu. ft	
	1946	1945
Alberta	40,097,096	40,393,061
Ontario	7,051,309	7,199,970
New Brunswick	541,010	653,230
Saskatchewan	209,569	163,824
Northwest Territories	1,500	1,500
Total	47,900,484	48,411,585

Total value of this gas was $12,165,050 in 1946 compared with $12,309,564 in 1945.

1948 *Estimates*

Preliminary estimates† by the Dominion Bureau of Statistics of the output of crude petroleum in Canada during 1948 show a total of 12,098,166 barrels (valued at $36,858,959), compared with 7,692,492 barrels ($19,575,682) in 1947. It is stated that striking developments in the Leduc, Alberta, oilfield were responsible for this new high level.

In 1948 natural gas production is estimated at 56,636,951 m. cu. ft ($14,608,689), against 52,656,567 m. cu. ft ($13,429,558) in the previous year.

* "The Canadian Mineral Industry in 1946", Canada, Department of Mines and Resources, Bull. 824.

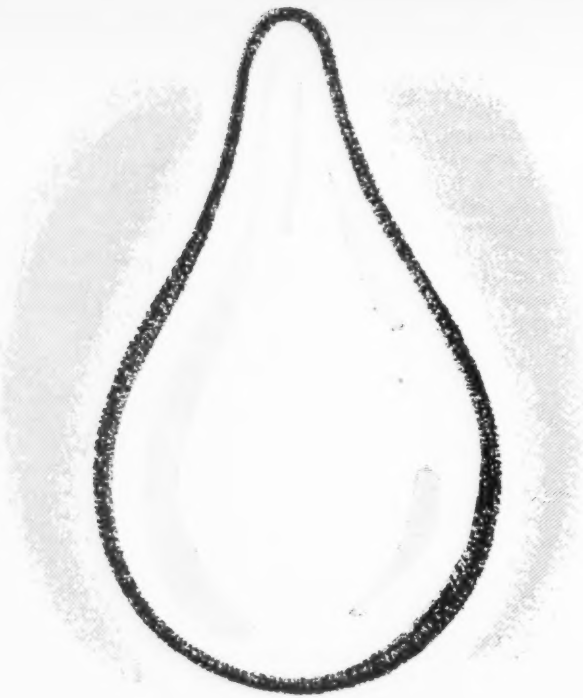
† "The Mineral Industry in 1948", H. McLeod. *Canad. Min. Metall. Bull.*, 1949, **42**, 30.

Leduc Natural Gas Plant. It is announced that Imperial Oil Ltd. are to build at Leduc a gas gathering system, compressor station, and gasoline plant. Capacity will be 24,000,000 cu. ft daily, and the plant will produce propane, butane, and natural gasoline. Cost is estimated at $6,500,000 and completion is expected by mid-1950.

CROP PROTECTION CONGRESS

Arrangements are being made for the Second International Congress on Crop Protection to be held in London during the period July 20–29, 1949. After an opening ceremony at the Royal Institution, sessions will be held at the Imperial College in six sections, as follows: (1) Insecticides; (2) Fungicides; (3) Plant growth regulators; (4) Toxicology of crop protection substances; (5) Methods of application; (6) Analytical methods and standardization.

Visits will be made to various research stations, and the membership fee is £2. Full details are available from the hon organizer, International Congress of Crop Protection, 56 Victoria Street, London, S.W.1.



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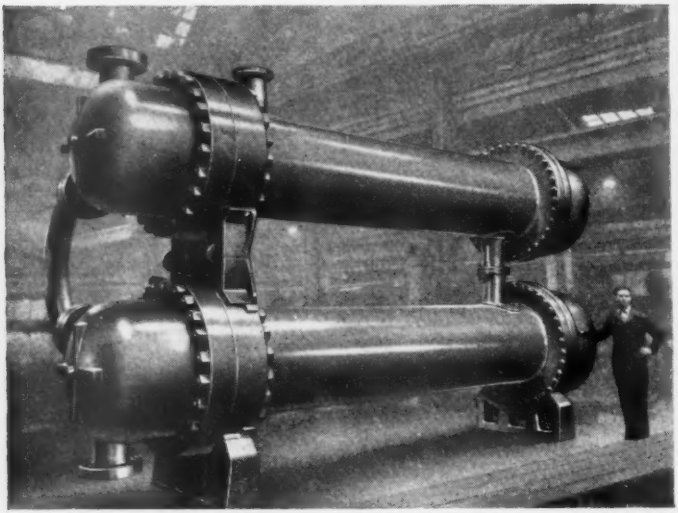

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